SA-388

File No. 1-0032

CIVIL AERONAUTICS BOARD

AIRCRAFT ACCIDENT REPORT

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UNITED AIR LINES, INC.
BOEING 727, N7030U
SALT LAKE CITY, UTAH
NOVEMBER 11, 1965

SYNOPSIS

United Air Lines, Inc., Boeing 727, N7030U, operating as Flight 227, crashed during an attempted landing at Salt Lake City Municipal Airport, Salt Lake City, Utah, at approximately 1752 m.s.t., on November 11, 1965. Of the 85 passengers and a crew of 6 aboard, there were 43 fatalities, including 2 passengers who succumbed in the hospital several days after the accident. The 48 survivors included all crewmembers.

The flight, scheduled from LaGuardia Airport, New York, to San Francisco International Airport, San Francisco, California, with several intermediate stops, departed Denver at 1654. Shortly after 1748 the flight advised ". . . Have the runway in sight now, we'll cancel and standby with you for traffic." The high, straight-in approach continued under Visual Flight Rules (VFR). Impact occurred 335 feet short of the runway threshold, the main gear sheared, and the aircraft caught fire and slid approximately 2,838 feet on the nose gear and bottom fuselage surface, finally coming to rest approximately 150 feet off the east side of the runway.

The Board determines the probable cause of this accident was the failure of the captain to take timely action to arrest an excessive descent rate during the landing approach.

1. INVESTIGATION

1.1 History of Flight

United Air Lines (UAL), Boeing 727, N7030U, operating as Flight 227, departed LaGuardia Airport, New York, at 1035.1/ Regular stops en route to San Francisco, California, included Cleveland, Ohio, Chicago (Midway Airport), Illinois, Denver, Colorado, and Salt Lake City, Utah. The flight to Denver was routine, and a crew change was accomplished.

Flight 227 departed Denver at 1654 in accordance with an Instrument Flight Rules (IFR) flight plan. The assigned cruising altitude was Flight Level 310 and the estimated time en route was 57 minutes. Approaching the Salt Lake City area, the

1/ All times herein are mountain standard based on the 24-hour clock.

flight requested the Salt Lake City Air Route Traffic Control Center (ARTCC) not to vector them over Provo. A discussion about the new arrival procedure for Runway 34L pointed out that the Lehi intersection,2/ 13 miles northeast of Provo and 23 miles southeast of the Salt Lake City Municipal Airport,3/ was the initial fix for westbound arriving aircraft. At 1735:45 clearance was issued to descend at the pilot's discretion to 16,000 feet, and in his acknowledgement the captain requested, ". . . let me know when we're sixty miles east of Lehi." At 1738:05 the ARTCC controller notified the flight that they were 60 miles east of Lehi and they responded, "Okay we'll start her down." The flight proceeded in accordance with radar vectors, passing 5 miles south-southwest of Lehi where a radar handoff to Salt Lake City Approach Control was effected. New clearance altitudes were given during the continuous descent and at 1747:00 the approach controller advised, "United seventy two twenty seven . . . five miles south of Riverton Fan Marker coming on localizer course cleared for ILS runway three four left approach." At 1748:10, in response to the controller's request for the aircraft's altitude, the pilot replied "Okay we're slowed to two fifty (Knots) and we're at ten (10,000 feet) we have the runway in sight now, we'll cancel and standby with you for traffic." Control of the flight was transferred to the tower and at 1749:40 landing clearance was issued. At 1752:1 the tower controller reported on the interphone to the watch supervisor, ". . . United's on fire just landed." The accident occurred in darkness.

The crew stated that during the flight from Denver to Salt Lake City the first officer was flying the aircraft under the direction of the captain. During the descent they penetrated an overcast approximately 6,000 feet thick, with the engine anti-ice on. While in the clouds, at approximately 16,000 feet, idle thrust and speed brakes were selected. At 11,000 feet the speed brakes were retracted and shortly thereafter visual reference with the field was gained. The anti-ice switches were turned off and speed reduction continued to the reference speed4/ of 123 knots, as the landing gear and 40 degrees of flaps were selected. The flight continued descending at approximately 2,000 feet per minute (See Attachment A) with a full "fly-down" signal on the ILS indicator. The UAL recommended rate of descent during the landing approaches is 6-800 feet per minute.

The flight crew testified regarding the sequence of events on the final approac as follows:

CAPTAIN - At approximately 6,500 feet m.s.l. he stopped the first officer from adding power. He estimated that 15-20 seconds later, at approximately 5,500 feet m.s.l., the first officer moved the thrust levers forward. When the engines did not respond, he moved the thrust levers to the takeoff power position, and assumed control of the aircraft. He estimated that this occurred about 1-1/4 miles from the runway at an altitude of 1,000 feet (5,226 feet m.s.l.), and at least 30 seconds prior to impact. Although he glanced at the engine instruments, he did not recall any readings.

2/ The intersection of 141-degree and 030-degree radials of the Salt Lake City and Provo VORTAC radio facilities, respectively.

3/ The airport is located at 40° 47' N latitude, 111° 58' W longitude. The published elevation is 4,226 feet.

4/ Reference speed is 1.3 times the stalling speed of the aircraft in the landing configuration.

FIRST OFFICER - Approximately 1-1/2 to 2 minutes prior to impact he attempted to apply power but the captain advised him to wait. About 30 seconds later he moved the thrust levers half way. When he realized that nothing was happening, he reached to apply full power but the captain was already on the controls. He estimated that full power was applied approximately 5-10 seconds, but no more than 15 seconds prior to impact. He did not observe the engine instruments, and he neither heard nor felt any engine response.

SECOND OFFICER - On short final the first officer started to apply power but the captain brushed his hand away and said "not yet." Finally the captain applied about half throttle movement 7-8 seconds prior to impact. He did not observe the engine instruments, but he heard the engines respond normally.

Many survivors, including two stewardesses, seated in the aft cabin section, and several eyewitnesses stated that the engines did spool-up[5/] prior to impact.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	0	43	0
Non-fatal	6	29	0
None	0	13	

1.3 Damage to Aircraft

The aircraft was destroyed by impact and ground fire.

1.4 Other Damage

The asphalt overrun, some runway lights, and flush mounted approach lights were damaged.

1.5 Crew Information

Captain Gale C. Kehmeier, age 47, held airline transport pilot certificate No. 83447 with type ratings in the B-727, B-707, B-707/720, DC-6/7, DC-4 and DC-3 aircraft. He also held flight engineer certificate No. 1355508. His date of hire was July 1, 1941. He satisfactorily completed an instrument proficiency check in the B-727 on August 2, 1965. He had accumulated a total of 17,743 hours of pilot time, including 334 hours in the B-727 and 1,510 hours in the B-720. He received a first-class medical certificate May 3, 1965, with the limitation that he must wear corrective lenses while exercising the privileges of his airman certificate. The captain testified that he was wearing glasses at the time of the accident.

Captain Kehmeier was upgraded from first officer on January 10, 1944. He progressed satisfactorily until he began transition training for jet aircraft in November, 1960. A UAL memorandum regarding this training stated:

"The following will outline the progress of Captain Kehmeier during his DC-8 transition program. Captain Kehmeier enrolled November 4 as a member of class #30.

5/ Acceleration of the engine to the selected revolutions per minute.

His progress during the Ground School phase of training was average as was his simulator training conducted by Flight Instructor (A), with the exception of the second period which was graded four. Additional simulator practice apparently corrected the problem and Captain Kehmeier proceeded to the flight training phase. In the earlier stages of flight training, Instructor (A), advised that while the performance was graded average, it was extremely marginal and was based primarily on the simpler maneuvers.

"After some difficulty in acquiring the proficiency necessary to pass a practice oral, Captain Kehmeier finally did attempt his oral exam and failed it completely. He was then removed from further flight training until such time as he was able to complete the oral exam. This entailed a considerable amount of additional ground school training and took approximately three weeks. Upon satisfactory completion of the oral exam, his flight training was resumed with Flight Instructor (B). When the areas of flight training involving the more complex aspects of pilot technique, judgment, etc., were encountered, Captain Kehmeier's performance deteriorated to the unsatisfactory stage. After approximately seven hours of instruction, Instructor (B) was unable to correct the deficiencies and a Flight Manager of Standards observer was requested for the flight on February 3. Captain (C) acted as observer on this flight and his evaluation and recommendation on the basis of this observation is attached.

"A review of Captain Kehmeier's record still indicates unsatisfactory performance in the areas of command, judgment, Standard Operating Procedures, landing technique and smoothness and coordination. On the basis of the above I recommend Captain Kehmeier's DC-8 transition training be terminated."

On February 6, 1961, his jet training was terminated and he returned to DC-6 equipment on which he was rated average to above average.

Captain Kehmeier again entered the jet program in May, 1962. He progressed satisfactorily through Boeing 720 ground school, simulator, and flight training, but his type rating in the aircraft was not issued until he had performed an additional period in the simulator. The FAA inspector conducting this flight check reported on December 17, 1965 that, "Due to the time lapse since this check was given it is impossible to recall every maneuver and how it was performed. I recall that it was necessary to repeat several items to achieve a satisfactory grade. The impression I received while conducting this check was that Captain Kehmeier was instructed and had the capability to fly this aircraft well. He would deviate from accepted procedures and tolerances enough to make the maneuver unsatisfactory. After a discussion of the tolerance we would accept and the proper procedure that was to be used, he would perform satisfactorily. Although all rating maneuvers were completed in the aircraft he was given a simulator ride before his rating was issued due to his failure to recognize a compass failure warning." His continued performance in the B-720 was satisfactory through December 31, 1963, at which time his Flight Manager reported in an annual Flight Officer Evaluation, "Has done a creditable job during period." On January 2, 1964, however, he failed to pass an instrument proficiency check. Comments on this flight referred to his ILS approaches, go-arounds, and landings with 50 percent power. He was high on the glide slope at minimums on two approaches, slow to add power on the first go-around, and selected full flaps too early in the simulated two-engine approach, which necessitated addition of power from the simulated inoperative engines. A recheck on January 4, 196? was passed satisfactorily.

Captain Kehmeier began training in the B-727 in January, 1965, and received a type rating in the aircraft on February 5, 1965. The FAA inspector in this instance reported, "Although I am unable to remember too much about the ride itself, I do recall a few items. The overall check ride was a little below average. The main outstanding thing in my mind was that he could fly the airplane but it was necessary several times to remind him to stay on altitude or airspeed." His last en route proficiency check was given on September 8, 1965, and he was graded above average.

First Officer Philip E. Spicer, age 39, held commercial pilot certificate No. 1155360 with airplane single and multi-engine land and sea privileges. He was hired on September 22, 1955, and had accumulated a total of 6,074 flying hours, of which 84 were in the B-727. His last en route proficiency check was accomplished on September 2, 1965, and was graded average. He was issued an FAA first-class medical certificate on June 22, 1965, without limitations.

Second Officer Ronald R. Christensen, age 28, held commercial pilot certificate No. 1556974 with airplane single engine land privileges. He also held flight engineering certificate No. 1590521. He was hired on January 27, 1964, and had accumulated a total of 1,027 flying hours. He had approximately 500 hours pilot time, and 166 hours as second officer in the B-727. His FAA first-class medical certificate was issued on October 4, 1965, without limitations.

The captain and second officer had approximately one hour of duty time in the last 24 hours. The first officer had 6:19 hours of duty time in the last 24 hours, with 12 hours of rest preceding this trip.

Stewardess Victoria J. Cole was employed on July 17, 1961, and received her last recurrent training on September 22, 1965.

Stewardess Faye B. Johns was employed on July 24, 1964, and received her last recurrent training on November 6, 1965.

Stewardess Annette P. Folz was employed on September 16, 1964, and received her last recurrent training on February 25, 1965.

1.6 Aircraft Information

N7030U, a B-727-22, manufacturer's serial No. 18322, was delivered to UAL on April 7, 1965, with a total flight time of 6:02 hours, and at the time of the accident had accumulated a total time of 1,781:39 hours. Maintenance was performed in accordance with FAA requirements.

The aircraft was equipped with three Pratt and Whitney JT8D-1 engines and serviced with kerosene fuel. The engines were installed as follows:

Position	Serial No.	Time Since Overhaul	Total Time
1	648819	1,675:13	3,257:13
2	648768	990:20	2,944:19
3	648953	2,310:05	2,310:05

The gross weight and center of gravity were within operating limits.

1.7 Meteorological Information

The 1755 surface weather observation at Salt Lake City was in part: 7,000 feet scattered, estimated ceiling 10,000 feet broken, 14,000 feet overcast, visibility 25 miles, temperature 44F, dewpoint 27F, wind 350 degrees 3 knots, altimeter setting 30.06 inches.

The 1615 Salt Lake City radiosonde ascent showed conditionally unstable air and increasing moisture from the surface to approximately 9,800 feet m.s.l., stable air above 9,800 feet, and moist air from that level to 27,000 feet. The freezing level was at 7,800 feet m.s.l. The crew reported that no icing was encountered.

Although no formal weather briefing occurred, the crew did refer to the self-help weather briefing boards prior to departure from Denver.

1.8 Aids to Navigation

All components of the ILS serving Runway 34L were operating within acceptable tolerances, and the crew stated that both receivers were tuned to the ILS during the final approach.

1.9 Communications

All transmissions from the flight were made by the captain. There were no reported problems with communications.

1.10 Aerodrome and Ground Facilities

Runway 34L is 10,000 feet long, 150 feet wide with a concrete and bituminous surface, and is equipped with high intensity runway lights and a standard approach lighting system. Both systems were operating and set properly at the time of the accident.

1.11 Flight Recorder

The flight data recorder on this aircraft, a Fairchild Model 5424, S/N 1540, was examined and there was no fire or mechanical damage found. The tape was in excellent condition and all parameters were functioning. The flight record was read out for the last 15 minutes. Approximately 14 minutes prior to impact a high speed descent from the cruising altitude of FL 310 began. The reduction in speed from 370 knots began at 10,200 feet, approximately 4-1/2 minutes from impact, as the descent continued. A stabilized approach speed of 123 knots was reached at 7,800 feet with slightly less than two minutes to impact. During the last 1-1/2 minutes of the approach the rate of descent exceeded 2,000 feet per minute and averaged in excess of 2,300 feet per minute in the last minute. At initial impact a vertical acceleration of +4.7-g occurred, and the other three parameters apparently did not scribe for a six-second time period. Although the acceleration peaks during the next several seconds reached total amplitudes of -1 to +6-g's some aberrations did occur.

1.12 <u>Wreckage</u>

The initial impact occurred 335 feet short of the threshold of Runway 34L at Salt Lake City Municipal Airport, and prior to contacting the threshold lights the right and left main landing gear began to separate from their attachment points.[6] The aft lower portion of the fuselage contacted the runway and the aircraft continued sliding on the fuselage and nose gear approximately 2,838 feet. During the skid it veered to the right and came to rest 150 feet east of the runway on a heading of 123 degrees. The No. 1 engine separated and came to rest approximately 140 feet north of the aircraft.

Examination of the wreckage revealed that the landing gear was down and locked, landing flaps and leading edge devices were fully extended, and spoilers were retracted. The horizontal stabilizer was set at 8-3/4 units noseup and sustained downward bending. There was no evidence of flight control difficulty prior to impact.

Severe upward and rearward impact forces from the right main landing gear assembly produced a large impact hole and ruptured fuel lines and the No. 3 generator leads between fuselage station 1030 and 1130 on the right side. The fuel was ignited by sparks from the fuselage scraping on the runway and/or the severed generator leads. The hole and fire damage area extended circumferentially from the lower sill of the aft cargo compartment door to the top of the fuselage. The entire roof and cabin area forward of this was consumed by fire which was initially being supplied fuel under pressure by the operating boost pumps. All flight control cables, fuel supply lines from the Nos. 2 and 3 tanks, and the No. 3 generator leads which are routed through the cabin floor beams in the area of the impact hole were consumed by fire. Only a 5/8 inch stainless steel hydraulic pressure line remained intact.

All systems were operating properly prior to impact, and the crew reported no difficulty or warning lights. They did not actuate any switches or controls prior to leaving the aircraft.

The left main landing gear crushed the lower half of the No. 1 engine air inlet cowl aft to the compressor inlet station. Foreign object damage (FOD) extended through all compressor and turbine stages of the engine. The No. 2 engine sustained heavy FOD on the first stage of the compressor, with additional damage sustained decreasing from the second through the seventh stages. The No. 3 engine received FOD throughout all 13 stages of both compressor sections, decreasing from severe at the front to slight at the rear.

All engines were found to be capable of producing rated engine power prior to impact. The eight fuel boost pumps were tested and only two, each from a different tank, failed to meet specifications. The compressor bleed valves, which facilitate spool-up of the engines, were all operationally tested and found satisfactory. Testing of the three engine fuel controls revealed that Nos. 1 and 2 were normal and No. 3 produced an engine response approximately one second slower than normal. The aircraft fuel tanks remained intact, and all fuel shutoff valves were open.

1.13 Fire

6/ The B-727 landing gear is stressed to withstand an impact velocity of approximately 12.5 feet per second.

There was no evidence of inflight fire. The survivors who were seated in the aft right portion of the cabin observed the fire initially enter the cabin from under seat 18E (right window seat) and erupt up the inside wall. Time estimates ranged from "immediately" to "one or two seconds after impact."

Two airport crash trucks arrived at the accident site within approximately 3-1/2 minutes. They were positioned on either side of the aircraft tail section where the flames seemed to originate. The fire was essentially contained within the fuselage which materially reduced the effectiveness of the firefighting efforts. The flames persisted, and there was a temporary cessation of firefighting until the water supply could be replenished by additional personnel and equipment from the Salt Lake City Fire Department. These units had been simultaneously notified of the accident and arrived within approximately 10 minutes. The fire was finally brought under control at about 1830.

1.14 Survival Aspects

This was a survivable accident. There were 91 persons aboard the aircraft and 50 were successful in evacuating, although many were severely burned and some sustained injuries during their egress. The remaining 41 occupants were overcome by dense smoke, intense heat, and flames, or a combination of these factors, before they were able to escape. There were no traumatic injuries which would preclude their escape. Two survivors died in the hospital several days after the accident, bringing the total number of fatalities to 43 passengers.

All emergency exits were available and used. The sliding windows in the cockpit were actuated and used by the captain and first officer. The press of passengers crowding in the area of the main loading door hampered the attempts of the stewardess to open it. However, the second officer succeeded in opening it completely, inflating the slide, and then directing the evacuation of passengers through this exit. The galley door, on the right side between rows 8 and 9, and the overwing emergency exit windows on either side at rows 12 and 14 were all opened by passengers. The emergency slide at the galley door was not actuated until a UAL stewardess, who had been riding as a passenger, was able to instruct a man to activate it. Both were outside the aircraft at that time.

When the aircraft came to a complete stop, the stewardess who was occupying the jumpseat on the aft passenger entry door, opened this door to see if the ventral stairway could be used for egress. However, the nose high attitude of the aircraft due to the extended nose gear and sheared main gear prevented the stairway from opening more than about six inches. Two men who were seated in the aft cabin area, preceded her into the stairwell. When she attempted to return to another exit the flames and smoke had blocked them off. They huddled as far from the approaching fire as possible, and at the suggestion of the stewardess began pounding on the fuselage and yelling to the firemen outside. The stewardess extended her arm through the narrow opening and succeeded in attracting the attention of firemen outside. A hose was passed into the stairwell and one of the men sprayed the surrounding area. All three persons were successfully rescued from the aircraft through the large hole which had burned through the aft cabin wall on the right side. Although there is no exact timetable for this unprecedented rescue it is estimated that the time envelope from impact to discovery of the survivors was approximately 23 minutes and that the rescue was completed between 25 and 30 minutes after the accident.

1.15 Tests and Research

Power response curves for the JT8D engines indicate that they will accelerate from idle to takeoff thrust in 6-8 seconds. Approximately 5 seconds of this time interval elapses before 50 percent of available thrust is developed.

Various performance curves approximating the accident conditions[7/] were developed from flight test data. They indicate that idle thrust is required to maintain a stabilized descent rate of approximately 2,300 feet per minute, in the landing configuration. From this condition it is possible to initiate a flare at 148 feet and land with a zero sink rate without any addition of power. This requires that the pilot rotate and maintain the aircraft in the stick-shaker[8/] attitude, which would produce an average acceleration of approximately ≠1.27-g throughout the maneuver. While this will result in some airspeed decay, the touchdown occurs well above the stalling speed.

A more normal recovery from such a rate of descent can be accomplished by flaring at an average landing flare rate, approximately ≠1.06-g, and adding sufficient power to maintain constant airspeed throughout the maneuver. This landing would require action by the pilot at 375 feet, with the maximum power requirement, 50 percent of takeoff thrust, occurring at an altitude of 50 feet. The power required decreases from this point on because of ground effect.[9/]

1.16 Crew Training and Certification Changes

On March 8, 1966, the FAA issued an order for all Principal Operations Inspectors to review their assigned air carrier's jet operating procedures and approved training programs. All operations manuals were to provide procedures to increase pilot awareness of altitude and descent rates. Further, pilot-in-command experience of 100 hours was established as a minimum level before he could allow the copilot to execute a takeoff, approach, or landing. The order imposed training requirements for a high rate of descent demonstration by pilots in command of turbojet aircraft. The maneuver shows the undesirable landing approach profile and its effects. Also the minimum numbers and types of landings were increased for pilots who were receiving their initial checkout in turbojet equipment. The new criterion of 35 landings, which may be reduced to 25 for exceptional pilots, requires at least six day landings and five night landings be made without reference to visual or electronic glide slopes. Additional special emphasis is to be placed on training in the proper use of artificial horizons and flight directors and the attitudes necessary to maintain level flight in various thrust and airplane configurations.

2. ANALYSIS AND CONCLUSIONS

2.1 Analysis

The evidence indicates that there was no significant malfunctioning of the aircraft systems or components. The separation of the landing gear and No. 1 engine

7/ Standard day, elevation 4,226 m.s.l, gross weight 135,711 pounds, c.g. 27.3 percent, 40 degrees flaps, gear down, 123 knots.

8/ The B-727 incorporates a stall warning device which shakes the control column at approximately seven percent above stall speed to alert the pilot. In this instance stall speed was approximately 93 knots.

9/ The effect of the ground or surface reducing drag and increasing lift of an airfoil operating in close proximity.

resulted from impact loading in excess of their design structural strength.

No icing was encountered in the overcast, and there is no evidence of other circumstances which would unduly delay response from the three engines. Therefore, it is concluded that if power application had been initiated at the proper time, sufficient power would have been available to successfully complete the landing in the normal manner.

As the flight approached the Salt Lake City area, the crew was briefed on the new procedure and the location of the Lehi intersection. The captain, who had previously requested not to be vectored over Provo, selected a point 60 miles east of Lehi for commencing his descent. Subsequent vectors given to the flight resulted in a flightpath quite similar to that which the captain customarily took, and if anything was closer to Provo, and farther south than he would normally have gone. The flight passed the outer marker, 5.7 miles from the runway threshold, over 2,000 feet above the normal glide slope, at an airspeed of approximately 200 knots. The approach was continued and further speed reduction accomplished. In the ensuing seconds the landing configuration, 40 degrees flaps and landing gear down, and the reference speed for the approach were established. Approximately one minute prior to impact, the rate of descent was approximately 2,300 feet per minute, nearly three times the recommended rate of descent for landing approaches, and the aircraft was still 1,300 feet above the normal glide slope. The captain's testimony indicates that it was about this time that he advised the first officer to wait before adding power. He further testified that he realized he was in trouble at 1,000 feet and 1-1/4 miles from the runway. The flight recorder indicates this point was passed about 30 seconds prior to impact. He indicated that thrust lever movement to the takeoff power position had failed to bring a response from the engines, although he did not recall the engine instrument readings. It was his opinion that the best indication of engine response was ". . . the seat of the pants."

The time estimates between the captain's power application and impact varied markedly among the flight crew. However, it appears that the 5-10 second estimate of the first officer, and 7-8 second estimate of the second officer are more in consonance with each other, and the testimony of eyewitnesses and passengers than the 30 seconds estimated by the captain. The physical damage to the No. 1 engine indicates that it was producing substantial thrust at impact. The foreign material ingested at that time penetrated all stages of the compressors and turbines. There was insufficient FOD in the Nos. 2 and 3 engines to accurately evaluate the power being developed at impact. However, there is no substantiation for slow response from either of these engines, and the Board believes they responded essentially the same as No. 1. The greater FOD in the No. 1 engine resulted from breakup of the air inlet cowl when it was struck by the left main landing gear. It is believed that the captain's estimate of full power application 30 seconds prior to impact is in error. If the thrust levers had been moved to the takeoff power position that early in the approach, the excess thrust would have been reflected in increased airspeed and/or decreased rate of descent.

UAL company procedures recommend that pilots where possible, maintain a descent with reference to the ILS glide slope. This will aid in maintaining the suggested 6-800 feet per minute rate of descent on landing approaches. In addition the pilots are warned that, " 'The highest rate-of-descent tolerable with a flare from 50 feet is just under 2,000 fpm and requires takeoff power to keep the speed at 1.3 Vs during the flare.' Obviously this is a hazardous configuration and should

not be allowed to develop." Although this approach was made under VFR conditions, the ILS system was on, functioning properly, and being received by the aircraft instruments. Despite the high rate of descent and position well above the glide slope portrayed on the instruments, and the previously mentioned guidelines for landing approaches, the crew continued the approach. This action was not only contrary to recommended procedures, but well beyond the parameters which are expected of a prudent pilot.

Both pilots testified that they had previously experienced the stick-shaker during training flights demonstrating approaches to a stall, but in the seconds immediately prior to impact they were reluctant to pull very hard on the control column for fear that the aircraft might stall. The captain did not execute a 360-degree turn in order to lose additional altitude in the approach, because in his judgment it was not needed and if the power had responded at the proper time the descent rate could have been arrested and a normal landing effected. The first officer did not execute a 360-degree turn because it was the captain's prerogative.

The entire jet training record of the captain reflects a spread of grading which ranges from unsatisfactory to above average. This variation is typified in his inability to complete the DC-8 training program due to ". . . unsatisfactory performance in the areas of command, judgment, Standard Operating Procedures, landing technique and smoothness and coordination." In the B-720 two years later he received above average grades for his command ability and judgment, qualities which do not normally vary so drastically. Grading on his landing techniques, ILS approaches, and adherence to proper procedures and tolerances also varied through his B-720 and B-727 instrument proficiency checks. Maneuvers rated below average on a given check ride were graded above average on the second attempt or on a subsequent flight, where a recheck was necessary. The comments of the two FAA inspectors who observed the B-720 and B-727 initial qualification flights of the captain give considerable insight into the captain's attitude. Both inspectors reported that they believed that while the captain had the training and ability to fly the aircraft well, he would deviate from accepted procedures and tolerances enough to make the maneuver unsatisfactory. Repetition of the maneuver following a discussion of the acceptable tolerances would result in a satisfactory performance.

The FAA flight check is designed to test a pilot's skills and techniques. The FAA inspector evaluates the applicant's overall piloting competence during the relatively short period of time involved in the check. This evaluation is usually done without the benefit of previous observation or knowledge of the applicant's performance during routine flight operations. Although the FAA, as part of its inspection system, periodically spot checks the carrier's pilot training and airman records it does not require an examination of these records as part of the certification and type rating process for each airman. The company records of this pilot were not examined as part of his B-727 flight check. The captain in this case did demonstrate to the satisfaction of the examining company check pilot and an FAA inspector that he possessed the knowledge and the ability to serve in

the capacity of pilot-in-command in the Boeing 727.[10/]

However, the responsibility and authority which the pilot-in-command has for the operation of a transport airplane also requires the exercise of sound judgment. Fulfillment of the pilot-in-command responsibility demands self-discipline in adherence to tested and approved procedures. In this instance the captain did not follow the approved procedure with regard to rate of descent during the landing approach to the Salt Lake City Airport.

The training records of this captain indicated a pattern of below average judgment, as well as a tendency to deviate from standard operating procedures and practices. Indeed, it is significant that in this case the history not only reflects an apparent indifference toward adhering to acceptable procedures and tolerances in general, but specifically during the landing or ILS approach phases of flight.

The areonautical knowledge and skill levels required for an airline transport pilot may be determined through testing, but the less tangible aspect of mature judgment may not be so readily measured or determined. Pilot-in-command aptitude should be evaluated through supervisory observation of piloting performance in the carrier's day to day operation. Safety in air transportation requires the air carrier to identify those pilots in need of more training and train them; and particularly to identify those pilots who are marginal or who have demonstrated a failure to adhere to proven procedures and reassign them to duties compatible with their capabilities and limitations.

The FAA Order, dated March 8, 1966 (See Section 1.16) provides needed additional training guidelines and qualification requirements pertaining to critical aspects of jet aircraft operations. But training in piloting techniques by itself cannot adequately compensate for a marginal aptitude for duty as pilot-in-command.

The impact of the crash did not produce any traumatic injuries which would have precluded the escape of every passenger. On the contrary, it was the speed with which the passengers progressed toward the exits that prevented the stewardess from reaching her assigned duty station for evacuation. Following the accident the stewardesses recommended that they be seated near emergency exits for all takeoffs and landings. This practice has been adopted by UAL as standard procedure on all B-727 flights. Inasmuch as all emergency exits were used during the evacuation it is not known how many additional lives, if any, might have been saved if the stewardess had been able to carry out her assignments.

An FAA committee similar to the FAA-Industry task force on crashworthiness, which evolved from the UAL DC-8 accident at Denver, Colorado, July 11, 1961, has been activated to study what remedial actions will preclude loss of life in survivable accidents in the future. This is a matter of grave concern to the Board and it is believed that the crash fire prevention research programs underway should be pressed with vigor, and that each improvement be incorporated at

10/ The Board has commented to the Administrator in support of the FAA Notice of Proposed Rule Making, No. 66-6, March 19, 1966, "Flight Maneuvers Required for Airline Transport Pilot Certificate and Certain Checks." In its comment the Board pointed out the changes proposed in NPRM 66-6 would result in more comprehensive and reliable flight test for evaluating a pilot's capability and competency to serve as pilot-in-command of aircraft used in air transportation.

the earliest possible moment. The Board's "Study of United States Air Carrier Accidents Involving Fire 1955-1964" lists various recommendations which, if implemented, would enhance passenger protection, survival and reduction of injuries. In that report the Board said:

"Progress in bringing about the required design changes, the incorporation of new concepts and equipment, and in the establishment of procedures and training to better indoctrinate passengers for survival in emergency situations is being made, but not as expeditiously as desirable. It is hoped that this study will act as a catalyst to accelerate improvements in these areas with respect to present aircraft and insure that the lessons of the past will be incorporated into the design and fittings of the new aircraft models soon to enter the civilian fleet."

2.2 Conclusions

(a) Findings

1. The aircraft, powerplants, and all systems were capable of normal operation.

2. The aircraft crossed the outer marker over 2,000 feet above the ILS glide slope.

3. The rate of descent during the final approach exceeded 2,000 feet per minute, approximately three times the UAL recommended rate of descent for landing approaches.

4. The Captain stopped the first officer's initial attempt to apply power

5. The power was applied too late to arrest the rate of descent and make a normal landing.

6. The captain's training records indicate a tendency to deviate from acceptable standards and tolerances.

7. The right main landing gear severed fuel lines and a cabin fire erupted seconds after impact.

8. All emergency exits were used.

9. This was a survivable accident.

(b) Probable Cause

The Board determines the probable cause of this accident was the failure of the Captain to take timely action to arrest an excessive descent rate during the landing approach.

BY THE CIVIL AERONAUTICS BOARD:

/s/ CHARLES S. MURPHY
Chairman

/s/ ROBERT T. MURPHY
Vice Chairman

/s/ G. JOSEPH MINETTI
Member

/s/ WHITNEY GILLILLAND
Member

/s/ JOHN G. ADAMS
Member

3. Recommendations

1. The Board is concerned that the procedures for pilot testing prevailing at the time of this accident were such that an individual with the pilot behavioral characteristics of the pilot in this case could qualify and be retained as pilot-in-command of a B-727 aircraft. The Board therefore recommends that both the Federal Aviation Agency and the air carriers reexamine existing procedures to the end that all feasible steps may be taken to make sure that airmen who serve as pilots-in-command of commercial aircraft, and in particular high-speed jet aircraft such as the B-727, possess not only the requisite technical skills, but the necessary qualities of prudence, judgment and care as well.

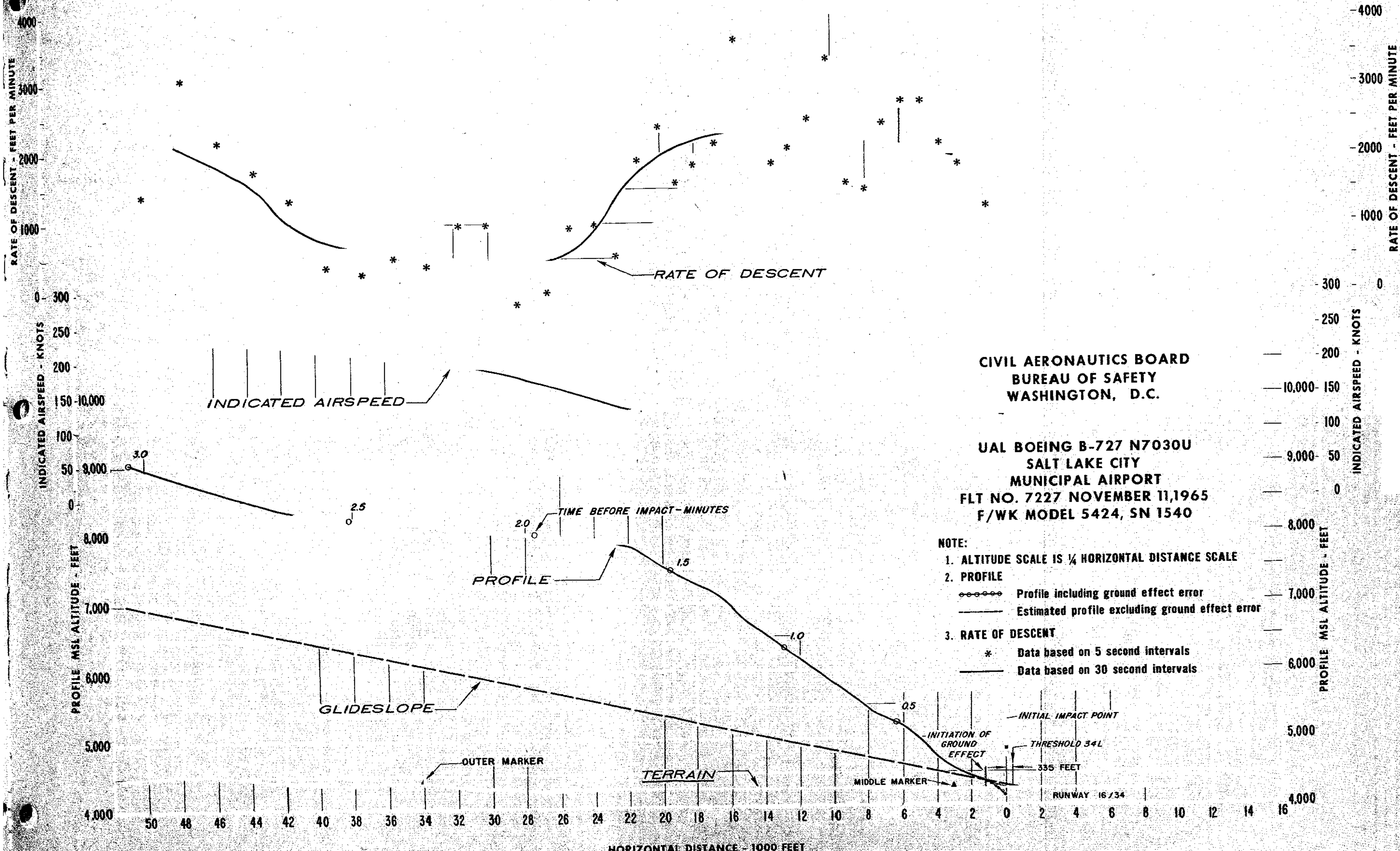
2. The Board believes that all operators of the B-727 should review the decision of UAL relative to positioning of stewardesses near exits, with a view toward adopting their practice.

3. The Board is also concerned about the loss of life in this survivable accident and recommends that the crash fire prevention research programs underway be pressed with vigor, and that each improvement be incorporated at the earliest possible moment.

4. Additional specific recommendations on the B-727 are set forth in Attachment B.

FLIGHT PROFILE

(BASED ON FLIGHT RECORDER DATA)



CIVIL AERONAUTICS BOARD
BUREAU OF SAFETY
WASHINGTON, D.C.

UAL BOEING B-727 N7030U
SALT LAKE CITY
MUNICIPAL AIRPORT
FLT NO. 7227 NOVEMBER 11,1965
F/WK MODEL 5424, SN 1540

NOTE:

1. ALTITUDE SCALE IS ¼ HORIZONTAL DISTANCE SCALE
2. PROFILE
   - Profile including ground effect error
   - Estimated profile excluding ground effect error
3. RATE OF DESCENT
   - * Data based on 5 second intervals
   - Data based on 30 second intervals

ATTACHMENT B

B-80-96

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NOV 30 1965

Mr. George S. Moore
Director
Flight Standards Service
Federal Aviation Agency
Washington, D. C. 20553

Dear Mr. Moore:

Our investigation of the November 11, 1965, accident of United Air Lines Boeing 727, N7030U, at Salt Lake City, Utah, has progressed to the point where we believe specific recommendations are in order in regard to the routing of fuel and electrical lines through the fuselage. We will probably have additional recommendations later concerning other design and operational aspects; however, further investigation and study are required beforehand.

It has been established with reasonable certainty that the fire following impact resulted from fuel lines being broken by the failed right main landing gear. This component broke through the fuselage sidewall in the vicinity of fuselage station 1050 and severed the fuel lines to the No. 2 and No. 3 engines. Ignition of spilled fuel could have been caused by sparks from runway contact or by a broken and shorted generator lead, or both. As you well know, the fire which followed was devastating and resulted in the loss of 43 lives.

It is interesting to note that in this accident both main landing gears struck the sidewalls of the rear fuselage after being broken free from their attachments. This directly rearward path of both gears indicates that the aircraft was not yawed appreciably at the time of impact and, therefore, we believe it is indicative of the natural failure pattern for any straightforward hard impact. In the past there have been many cases of landing gears being torn from aircraft because of low approaches over dikes and other obstructions and because of landings short of runways followed by the curbing of the gear on the paved runway end. Since there is no reason to believe that the 727 will not be subjected to similar treatment, it is imperative to afford a higher degree of survivability following such accidents. We, therefore, make the following recommendations:

1. Fuel lines through the fuselage should be rerouted that they pass through the floor beams near the centerline of the aircraft.

2. The fuel lines and their shrouds should be made of stainless steel and should have a wall thickness of sufficient dimension to withstand rather severe impacts. We suggest that the wall thicknesses be not less than 0.040 inch.

3. The generator leads should be routed so that there is maximum separation between these leads and the fuel lines. Each lead should be in a separate plastic conduit with suitable strength and flexibility to withstand bending and reasonably high tensile load.

In regard to recommendation No. 1 above, it should be pointed out that his aircraft struck the ground with a recorded impact of 8.9 g's after the landing gear failure but despite this heavy impact the aft fuselage belly structure did not collapse. In other words, had the fuel lines been running through the center area of the floor beam, they would have been adequately protected. In support of recommendation No. 2, it was noted during the investigation that although the aluminum tubing and shroud of fuel line No. 1 did not melt, those of lines No. 2 and No. 3 did melt in areas other than the break points. Thus, fire from one broken line could melt through the present aluminum tubing and shroud of another line and thereby increase the intensity of an existing fire.

It is our understanding that both FAA and Boeing personnel who participated in the investigation of the Salt Lake City accident have made similar recommendations through their own organizational channels.

We also recommend that all other similarly configured aircraft (e.g., DC-9, Lear Jet, Caravelle, BAC 111, Jet Commander) be the subjects of a study to determine whether or not analogous dangers exist in their fuel and electrical system geometries.

Should your staff desire further information or wish to discuss the problem further, we can make appropriate members of the investigating team available at any time.

Sincerely yours,

/s/ B. R. Allen

B. R. Allen
Director, Bureau of Safety

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November 30, 1965

Mr. George S. Moore
Director
Flight Standards Service
Federal Aviation Agency
Washington, D. C. 20553

Dear Mr. Moore:

The United Air Lines Boeing 727 aircraft accident at Salt Lake City, Utah, on November 11, 1965, disclosed the possibility of mal-operation of the emergency lighting system which failed to illuminate the emergency exits for passenger escape to safety. To date there has been no substantiation of any lighting in the cabin area after the aircraft came to rest.

The system is designed to be operated by a three-position switch in the cockpit overhead electrical panel. An amber indicator light adjacent to the switch monitors switch position and availability of 28 V DC power from battery bus.

OFF - lights "OFF," batteries not charging, indicator light "ON."

ARMED - lights "OFF," batteries charging if AC and essential DC power available, indicator light OFF. If AC and battery bus DC power fails, lights "ON." Indicator light remains "OFF."

ON - lights "ON," batteries discharging, indicator light "ON."

However, if the switch is left in the "ARM" position and the DC battery bus is still a complete circuit, the lights will remain "OFF." This is the situation that undoubtedly took place.

To eliminate this physical operation during a period of emergency, it is recommended that a procedure be used so that the emergency lights are turned "ON" during all takeoff and landing operations of Boeing 707, 720, and 727 aircraft, as well as all other turbine powered aircraft with automatic emergency lighting systems. Also, the aircraft should be rewired so that a loss of electrical power source for normal cabin lighting activates

the emergency lighting. The reverting to the self-contained nickel batteries in event of complete loss of aircraft electrical power should be retained.

It is further recommended that a study of all other type aircraft be made to ascertain the operating features of their emergency and exit circuitry to assure the emergency lighting operating during any emergency.

The above was discussed with your Airframe Section electrical engineer, Mr. E. Heil.

Sincerely yours,

/s/ B. R. Allen

B. R. Allen
Director, Bureau of Safety

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B-80-96

DEC 16 1965

Mr. George S. Moore
Director
Flight Standards Service
Federal Aviation Agency
Washington, D. C. 20553

Dear Mr. Mcore:

This is a further recommendation based on our investigation of the United Air Lines Boeing 727, N7030U accident at Salt Lake City, Utah, on November 11, 1965. As you know, 43 of the 91 occupants died as a result of this accident. Our preliminary findings indicate that none of these fatalities were due to traumatic injuries but all died from suffocation during the resultant fire. This is evidenced by the elevated carboxyhemoglobin concentrations in the victims and lack of trauma.

We are conducting an extensive study in the human factors area to determine how the survivors evacuated the airplane, the difficulties they experienced and the time it took them to evacuate. It is hoped that we will be able to determine the fire progression in the occupiable area of the cabin. Preliminary information indicates that the interior furnishings contributed greatly to the spread of fire and the emission of heavy black smoke, both of which contributed to the fatalities.

We understand that the Aircraft Development Service of FAA has just completed a study of air transport passenger cabin fires and materials and that their report will be published shortly after the first of the year. We have been advised that the aforementioned fire tests have disclosed a number of deficiencies in the materials presently being installed in aircraft interiors and that materials are available which would be far superior to those being used today.

We do not have complete information regarding the testing methods used during the aforementioned study by the Aircraft Development Service. We believe that the toxicity of the resultant gases produced by the combustion of various combinations of materials used in aircraft interiors might be worse than those produced by the materials individually. If the tests did not include such determinations it is recommended that they be expanded to test various combinations. Additionally these combinations should be tested with fuels carried in aircraft.

The Federal Aviation Regulations, in our opinion, should be updated to require newly certificated airplanes to be fitted with these newer materials which have been found to be less susceptible to combustion. Additionally, it is recommended that the air carriers be strongly encouraged to utilize these materials when they refurnish their airplanes.

Upon completion of our factual report on this evacuation we will forward a copy to you. In the interim, if additional information is desired, feel free to contact Mr. Doyle in our Human Factors Section.

Sincerely yours,

/s/ Robert L. Froman

for B. R. Allen
Director, Bureau of Safety

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FEDERAL AVIATION AGENCY

Washington, D. C. 20553

January 13, 1966

Dear Mr. Chairman:

This is in reference to letters from the Director, Bureau of Safety, Civil Aeronautics Board, two dated November 30, and one dated December 16, 1965, containing recommendations resulting from your investigation of the United Air Lines, Boeing Model 727 accident at Salt Lake City, Utah, on November 11, 1965. These were acknowledged respectively, on December 8, 10, and 27, 1965. We have studied your recommendations and are pleased to report that we have had many of them under consideration for some time. As you know, the details of many of the points will take time and resources to fully reconcile, but will be resolved as soon as possible.

The Agency safety program relative to the areas mentioned in your letters is outlined below:

Fuel lines and generator leads

Concerning your recommendation to relocate the fuel lines in the Boeing 727 near the centerline of the aircraft, our evaluation of this indicates the present location is the best possible because the lines are surrounded by the heaviest structure available in their present locations. If the fuel lines are moved inboard toward the center of the airplane, they will then be susceptible to rupture by items in the cargo compartment in the event of a belly landing which is the more conventional type of damage anticipated in emergency landings. We note in the Salt Lake City accident that the bottom of the fuselage was crushed upward approximately 20 inches. It is for this reason that the fuel lines were initially located in their present position. It is recognized that the fuel lines can be strengthened and their resistance to impact or shearing type failures can be improved. Engineering design studies are now in process to develop such improved type lines on a retrofit basis.

In regard to your recommendation to use stainless steel lines and shrouds, the redesigned configuration being studied is expected to include a neoprene core, stainless steel sheathing, and a teflon-type covering. The aluminum alloy shrouding will be retained since it is less prone to cutting or shearing of the fuel lines.

With reference to your recommendation to relocate the generator leads, the present electrical leads in the area of the fuel line will be rerouted to a near center position in the fuselage to separate them as far as practicable from the fuel lines. A teflon-type cover is being considered for the generator leads so that even if the bus is ruptured due to an impact load, the flexible cover will remain intact under deflection and thus reduce the likelihood of ignition of a fire.

We note your observations concerning landing gear failure on the Boeing 727. An engineering review of the landing gear design has been completed and the conclusion reached that a corrective measure is needed. The change will improve the response rate of the upper side brace tube attachment fitting so that without reducing the strength of this fitting for normal loads, the attachment fitting will fail after a small angle rotation toward the rear. A retrofit design change is in process.

Emergency cabin lighting systems

With reference to your recommendation concerning emergency lighting system operation and design, the emergency cabin lighting circuitry is being looked at very carefully. The present system provides for the battery powered emergency lights to go on after an interruption of either DC or AC power. The burning of the emergency lights during each takeoff and landing would deplete the batteries which have approximately 20 minutes capacity. The recharging rate would not be sufficient to assure emergency lights when needed. Our evaluation has not yet been completed of the full impact of the re-engineering and modification of systems to provide the capability of manually turning on emergency exit lights using airplane power during each takeoff and landing. Our attention will be given to similar designs in other transport aircraft.

Flammability of cabin interior materials

The Agency endorses and has recognized the need for more stringent requirements to define the characteristics of cabin materials when exposed to fire. Research action to improve these standards was initiated in early 1963 to investigate this problem. Subsequently Federal Aviation Agency Technical Report No. ADS-3, dated January 1964, and entitled "Flammability and Smoke Characteristics of Interior Aircraft Materials," served as part of our basis for a related regulatory project. Proposed new fire protection standards for aircraft cabin interior materials are being processed by the Agency to require self-extinguishment burn characteristics for such

materials on transport aircraft. Our research effort is also being applied currently to toxicity and smoke propagation characteristics of all materials used in transport airplane interiors and may well lead to further proposals to amend the related airworthiness standards. These projects are identified as "Thermal Criteria for Interior Materials" and "Hazardous Combustible Characteristics of Cabin Interior Material."

From the foregoing, I believe you will agree that evaluation of the need for corrective action on the Boeing 727 series aircraft is well underway. I would also like to make it clear that while the attention is focused on the Boeing 727 series, our consideration will also be given to other transport aircraft. Reassessments of transport aircraft with engines mounted in the rear are presently in process and may well lead to their further improvement.

Every effort is being directed by the Agency to continuously seek improvement of crashworthiness safety features. In consonance therewith, we are reactivating our task force to again reevaluate the adequacy of such provisions in transport airplanes and related operating procedures. This is timely as a followup to our recently adopted emergency evacuation rules. As part of this program, you will also be interested in knowing that the Agency plans to hold a series of meetings in the coming weeks with all segments of industry to stimulate constructive ideas for improvements in crashworthiness standards. As your Mr. Bernard Doyle was a member of the original task force, we would be pleased to have him participate as an advisor.

In summary, may I state the Agency is acutely aware of the need to continuously seek improved crashworthiness standards, and to improving the means to evacuate passengers under the most extreme conditions. We shall continue to devote our maximum efforts toward these objectives. It is extremely gratifying to me to know that the actions which the Agency either has had under consideration, or now is contemplating, have your support.

Sincerely,

/s/ William F. McKee

WILLIAM F. McKEE
Administrator

Honorable Charles S. Murphy
Chairman, Civil Aeronautics Board
Washington, D. C. 24028